

Recycling of Abandoned Concrete and Waste Asphalt in Road Construction

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Abstract—The present recycling situation of waste concrete and waste asphalt mixture was analyzed in the paper. It was obtained that a large number of them was not recycled in China. Recycling methods of waste concrete and waste asphalt mixture were studied and performance of recycled material was analyzed. Several pieces of advice were given to better recycle waste concrete and waste asphalt mixture.

Keywords- solid waste, recycling treatment, road construction

I. INTRODUCTION

With the acceleration of urbanization process, the construction and transportation industries have experienced rapid development in China. Meanwhile, the output of construction waste and road maintenance waste have increased day by day. Abandoned concrete tops the wastes in construction industry. The amount of annual abandoned concrete is 20 million t merely in Shanghai and more than 100 million t in the whole nation. Asphalt pavement, the main type of road surface, varies slightly from country to country. Under normal circumstances, Asphalt road surface makes up about 70% to 80% of road pavement. Generally speaking, asphalt pavement design life is 15 years, and usually it needs repairing in large scale each ten years. Large-area maintenance and milling will produce a great deal waste asphalt mixture. Bitumen, a type of hydrocarbon polymer, is extracted from petroleum. Its degradation time is much longer than that of the white trash, and during the process it will produce benzene, phenol and other substances. In the past, measures like landfills were employed to deal with concrete and asphalt, which will occupy land and lead to threat to the surrounding environment as well as a waste of resources. Moreover, mining, accompanied by the destruction of vegetation will have a negative effect on the environment. Therefore, the necessity of the waste concrete and asphalt recycling will be discussed in this paper.

II. STATUS OF ABANDONED CONCRETE AND WASTE ASPHALT RECYCLING

A. Status of Abandoned Concrete Recycling

The afresh utilization rate of the abandoned concrete and other construction waste has reached 56% in Tokyo in 1988; In 1996 the Kobe earthquake led to many damages of highways and bridges, collapse of buildings and 1,500 t waste concrete, which was used in post-earthquake reconstruction. According to the statistics of Ministry of Construction, the abandoned concrete recycling rate reached 65% in Japan in

1995, and 96% in 2000. "Li Fu Mu System", a decoration company in South Korea can separate cement from stone and steel in abandoned concrete and produce recycled concrete by heat treatment of cement under the high temperature about 700°C with adding special material.

An urban construction (group) in Beijing has saved 3.5 million Yuan during the process of building 9-million-m² area with different structure types of multi-layer and high-rise building by recycling various construction waste about 840 t. The construction waste was used in bonding mortar, interior wall and ceiling plastering, fine stone concrete floors, and concrete cushion with the total area of more than 30,000 m² and it helped save more than 35,000 Yuan. Abandoned concrete was employed to pave a "recycled road" in July 2003 in Tongji University. In July 1990 in Shanghai, in the projects named "Hua Ting" and "Holland" (total floor area of 137m² with the wall or frame structure) in the center of Shanghai, construction waste was recycled by the Second Construction Company.

B. Status of Waste Asphalt Recycling

In 1980, 395 million dollars was saved by using old road surface material about 5000×10^4 t in the United States. In the late 1980s, dosage of regenerative asphalt mixture accounted for almost half of asphalt mixture for all way-used in America. Great achievements were made in areas such as regenerating development, regeneration mixture design, construction equipment etc., and published "Asphalt Pavement Hot Mix Regenerated Technology Handbook", "The Pavement Waste Regeneration Guide", "The Asphalt Pavement Cold Mix Regenerated Technology Handbook Technological Data" and so on were published one after another. In September 2000, "Hot Mix Asphalt Mixture Regeneration Utilization Status" (Recycling Practices for HMA), with its main contents of recycling of waste asphalt and waste recycling in road works was published by American Asphalt Road Association (NAPA). In 2000, 80% waste asphalt mixture was regenerated and utilized, which was the first among various types of waste recycling. 92% of highways and general roads in the United States was made of asphalt pavement. Recycled asphalt mixture (RAP) is widely used in new pavement, subgrade, shoulders, and high fill embankment. According to the research by Federal Highway Administration (FHWA), recycled asphalt mixture can reduce by 53.4% in materials cost, 25% in pavement cost and 50% in asphalt. Japan, a country short of

Supported by Hydro-Science and Engineering of Chongqing Jiaotong University, the Key Laboratory Foundation Project of Ministry of Education (SLK2007B05)

resources, took the research of regenerating technology seriously. Road surface waste material regeneration utilization rate has already exceeded 70% from 1976 to now, and subsidies will be given to enterprises by the government according to the amount of waste asphalt they use. In Japan, hot mix asphalt was used (7861×10^4 t) in 1997, among which 29% (2284×10^4 t) of them were new asphalt and 71% (5577×10^4 t) were recycled asphalt. At present almost all of the waste asphalt mixture has been put into use in Japan. In 1978, Germany had all the waste asphalt recycled. Almost all towns in Finland organized to collect and store the waste road material. In the past recycled materials were mainly for low-grade highway pavement and grass-roots, while in recent years they have been applied to constructing important roads. Recycled asphalt mixture was widely used in pavement construction of heavy traffic and highways in France. Waste asphalt mixture recycling technology was earlier studied in the former Soviet Union. By the late 1980s, 1400t asphalt material by asphalt pavement regeneration technology had been saved merely in Leningrad City.

At the beginning of 1970's, waste asphalt was used to build roads in varying degrees in our country, most of which was considered waste utilization. It was generally for light traffic, sidewalks or road construction cushion. In 1983, a research project called "Recycling of Waste Asphalt Mixture", issued by Ministry of Construction, was undertaken by Shanghai Municipal Engineering Research Institute, Wuhan Municipal Engineering Design Institute and Tianjin Municipal Engineering Research Institute to soften roads and replace conventional asphalt mixture. Level is to deal with the following layer and mixing equipment should be improved. After 3 years of hard work, 30,000m² experimental road had been paved in Suzhou, Wuhan, Tianjin and Nanjing. However, after 1990, little research was conducted in waste asphalt recycling, which lead to wide gaps between home and abroad in areas such as recycling agents development, Recycled mixture design, renewable equipment development etc. With the arrival of maintenance of earlier highway in large scale, and further sustainable development and environmental protection issues on the agenda, the recycling of waste asphalt mixture draws our attention again.

III. RECYCLED PROCESSES OF ABANDONED CONCRETE AND WASTE ASPHALT MIXTURE

Crushing and screening abandoned concrete, using high performance aggregate to replace natural aggregate, and pouring cement stabilized layers in road surfaces and cement concrete layer are the ways to recycle abandoned concrete in road construction (Lusong Wang, 2007), while the remaining part is used as backfill material (Jinxi Zhang, et al. 2005). Waste asphalt mixture should be heated and stirred with reducing agent firstly, and then we add new material and new asphalt mixing to form recycled asphalt mixture (Li Jiang, et al. 2007).

A. Recycled Process of Waste Concrete

The process of making recycled aggregate by abandoned concrete is as same as the one by natural aggregate. Put all kinds of crushing equipment, screening equipment, transmission equipment together to produce aggregate. (Lusong Wang, 2007). The production process is as follows (Chuanfu Bao, et al. 2007):

1) Crushing

Pavement aggregate processing usually uses jaw crushers or hammer crushers. Jaw crusher crushes stones by compression in crushing chamber, which is mainly for aggregate processing of hard stone (compressive strength at 100~200MPa). Hammer crusher crushes stones with a high-speed rotation of the hammer, which is generally used for lower aggregate strength (compressive strength less than 70MPa) processing. Compressive strength of abandoned concrete is about 30~45Mpa, but lower than natural stone. Therefore, hammer crusher is suitable for the processing of recycled aggregate. Steel should be removed before crushing abandoned concrete.

2) Screening

To ensure the performance of recycled road aggregate, screening aggregate must be a step. Vibratory screener and roller screener are two main screening equipments used, while vibratory screen does better. Aggregate will be screened to size like 0~5mm, 5~20mm, 20~40mm, etc. by vibration screening (Chuanfu Bao, et al. 2007). Recycled aggregate can be classified by size of recycled coarse aggregate size (particle size of 5~40mm) and recycled fine aggregate (particle size of 0.15~2.50mm) (Lusong Wang, 2007).

3) Impurities Clearing

The recycled aggregate after crushing and screening, with its surface containing lots of dust and other impurities, is different from the aggregate produced by natural stone and can affect the strength of concrete. Therefore screening should be followed by impurities clearing, and high pressure water should be used to wash the surface of aggregate. To make construction more convenient, different types of aggregates should be stored separately after screening (Chuanfu Bao, et al. 2007). Recycling technology of abandoned concrete is shown in Figure 1 (Huafeng Qi, 2008).

B. Recycling Process of Waste Asphalt Mixture

Recycled asphalt production equipment combines original batch asphalt mixing machine and equipment of crushing and heating for old asphalt additionally. Original equipment is used for heating and measurement of new mineral aggregates and new asphalt, while new equipment is for heating and measurement of old asphalt and regenerant (Xinyu Shi, 2008). Old asphalt after heating is mixed with regenerant, new aggregate, new asphalt and slag in asphalt mixture stirrer. After mandatory mixing, old asphalt is turned

into recycled asphalt mixture (Yingzhi Xia, et al. 2008). The production process is as follows:

1) *Crushing and Screening of Waste Asphalt*

After carrying old road asphalt mixture to the factory, it should be crushed and screened after removing impurities. Then the aggregates should be divided into two types: 0~10mm and 10~25mm. Aggregates with large soil content and low utilization value should be handled separately (Wenxue Wu,2007).

2) *Performance Analysis and Mix Design of Old Asphalt Material*

Due to the differences of asphalt pavement, built time, the pitch variety or type of asphalt mixture, the old asphalt material from different sources should be analyzed to measure asphalt content, aggregate gradation and asphalt aging time. Then new aggregates, new asphalt and the amount of recycling agent should be added to design recycled asphalt mixture ratio (Xinyu Shi, 2008).

3) *Production Process of Waste Asphalt Mixture*

The new and old asphalt aggregates are transported to respective heating rollers to heat. New aggregates are directly heated by the flame and old mixture is heated indirectly by hot air to prevent the asphalt aging or burning. Heated new aggregate, old mixture, asphalt, slag, recycled materials, etc. are put into mixer to mix. The process is shown in Figure 2 (Xinyu Shi, 2008).

C. *Performance Analysis of Recycled Abandoned Concrete Aggregates*

Physical properties (such as apparent density, workability, water absorption and so on) of recycled abandoned concrete aggregate are different from those of natural aggregates (Cheng Wang, et al. 2010) .

1) *Low apparent density*

Apparent density of recycled aggregate is lower because of rubble and high porosity.

2) *Poor workability*

Workability of recycled aggregate is poorer because of its coarse surface.

3) *Larger water absorption*

Water absorption and water absorption velocity of recycled aggregate are larger because cement mortar (about 30%) covers the surface. Recycled aggregates have a lot of tiny cracks due to damage accumulation when waste concrete is crushing and disassembling.

D. *Physiochemical Performance Analysis of Recycled Asphalt*

Spent asphalt was extracted by industrial benzene from waste asphalt mixtures of Shenda, etc. 5 highways by Yonggang Wang, et al. Composite agent, spent oil selected from lube refining process was blended with the recovered spent asphalt and new asphalt(Yonggang Wang, et al. 2003). The blended asphalt could meet the standards of heavy-duty road asphalts (GB 50092-96), and its penetration, ductility, and other key indicators were better than the standards, which could completely replace new asphalt in road construction.

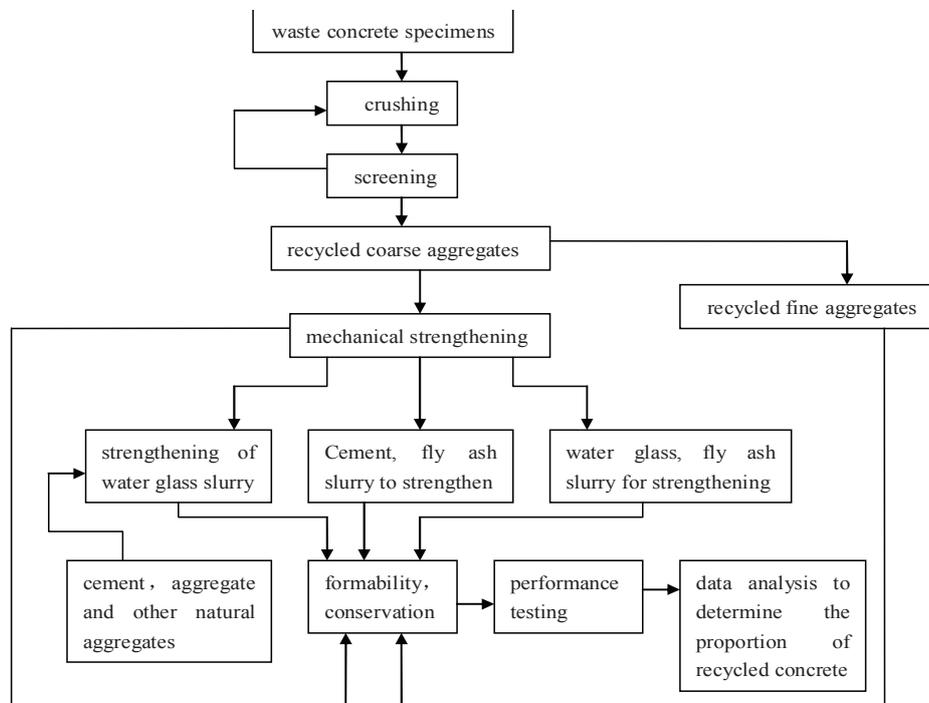


Figure 1. Recycling Technology of Waste Concrete

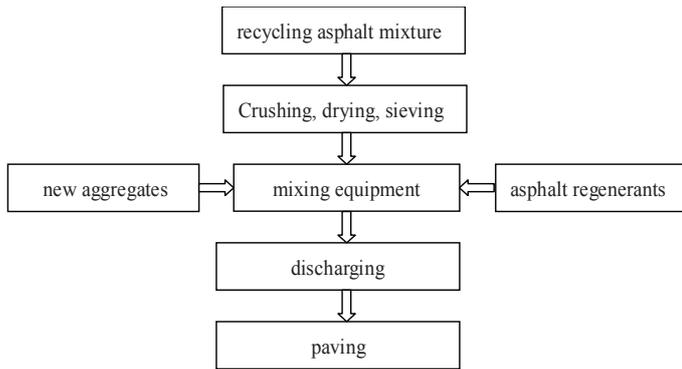


Figure 2. Mixture Process of Waste Asphalt

IV. CONCLUSION

A lot of waste concrete and asphalt mixture can lead to serious environmental pollution problems. Recycled aggregate processed by waste concrete and recycled asphalt by waste asphalt mixture can be used in road construction, which not only solves the problem of environmental pollution, but also achieves resource recycling to reduce waste of resources and energy. In order to achieve sustainable waste recycling, basic theories and related tests should be studied, and another two aspects should be strengthened in future: (1) develop and establish recycling specifications, standards and applications of waste concrete and waste asphalt mixture;(2) the government should establish relevant laws and regulations and give

financial support in order to promote the reuse of waste concrete and waste asphalt mixtures.

REFERENCES

- [1] Lusong Wang. Solid waste in road construction engineering[J]. Advanced Materials Industry, 2007,(5):48-50(In Chinese).
- [2] Jinxi Zhang, Juan Li. Present Situation and Task of Recycling Waste Asphalt Mixture in China[J]. Municipal Engineering Technology, 2005,23(6):340-348(In Chinese).
- [3] Li Jiang, Yelei Liu. Recycle of Waste Asphalt Mixture[J]. Journal of Northeast Forestry University, 2007,35(2):88-89(In Chinese).
- [4] Chuanfu Bao, Qizhen Wu. Research on Reuse of Regenerated Scrap Concrete[J]. Municipal Engineering Technology, 2007,25(6):447-448(In Chinese).
- [5] Huafeng Qi. Research on Application of coal gangue resource[J]. Coastal Enterprises and Science & Technology, 2008,(12):10-12. (In Chinese).
- [6] Xinyu Shi. On Recycling Mixture of Asphalt Waste[J]. Friend of Science Amateurs, 2008, (9):56-58(In Chinese).
- [7] Yingzhi Xia, Xinmin Liu. Experimental analysis of recycled asphalt mixture[J]. Journal of Pingdingshan Institute of Technology, 2008,17(6):72-74(In Chinese).
- [8] Wenxue Wu. Test Study on Road Performance of the Flyash Asphalt Mixture[D]. Master Thesis of Chongqing Jiaotong University,2007(In Chinese).
- [9] Cheng Wang, Huisheng Shi. Advancement in the Recycling Technology of Waste Concrete [J].Materials Review 2010,24(1):120-124(In Chinese).
- [10] Yonggang Wang, Kejian Liao, Feng Yan, et al. Study on Regeneration Technology for Waste Asphalt Mixture[J].Petroleum Processing and Petrochemicals,2003,34(9): 25-27(In Chinese).